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ABSTRACT

This brief paper discusses in some detail several recent studies of electrical-electronics curricula at the junior college level and presents a 22-item bibliography of studies in this area. Comments based on the findings of the studies include: (1) A method of instruction, particulary applicable to the field of electronics education, seems to be that each course in such a curriculum can be broken down into a list of required objectives, which is further enhanced for the student by the close coordination required with industry to obtain a detailed objectives list for an entire curriculum, (2) Circuit analysis and basic electronics should be part of the first year curriculum, (3) A core studies program in electronics can be developed, (4) The trend is toward hybrid technologies. The paper indicates more research is needed to ascertain emerging technologies which may require new course developments. Bibliographies, suggested curricula, and charts are included. (NH)

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AN OVERVIEW OF RECENT STUDIES IN JUNIOR COLLEGE ELECTRICAL-ELECTRONICS CURRICULUM

by

Harry E. Williams

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The objective of this paper is to briefly summarize several recent studies concerning electrical-electronics curriculum in the junior college and to [illegible] bibliography of studies in this field. Of particular [illegible]are (1) the original motives for the study, (2) the means [illegible]nich the studies were carried out, and (3) the conclusions reached with respect to recommendations for electrical-electronics curriculum.

Part of the inspiration behind this investigation stems from a visit to Centralia College in November, 1972. A conversation with Mr. Royce K. Hull, electronics instructor at Centralia, revealed that he felt there was a general lack of resource information in two particular areas - (1) follow-up studies on graduates to determine the extent of their success in industrial work and (2) studies to determine the most suitable content for the curriculum of the second year of an electrical-electronics program.

Investigation seems to show that Mr. Hull is correct concerning the paucity of follow-up studies on electrical-electronic technician graduates. This is best summed by Lewis Fibel's conclusion in a 1972 publication that research was particularly needed to measure curriculum effects on the future of the students - on how each course related to the person's ability to perform and advance on the job.[1]

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1. Fibel, Lewis R., Review and Synthesis of Literature on Occupational Preparation in the Community College, Columbus, Ohio; ERIC Clearinghouse on Vocational and Technical Education:(ED 061 416); March, 1972; pp. 46-47.

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Inquiry into Mr. Hull's second comment regarding curriculum studies for electrical-electronic programs led directly to this paper. As my graduate work will involve the development of some phase of curriculum in this area, this paper is also pertinent to future research.

The researcher in the field of electrical-electronic junior college technical education quickly discovers that a large amount of published material has been made available in recent years. The studies investigated cite as sources government agencies, such as the U.S. Office of Education, and State education offices, as well as the American Association of Junior Colleges. Fibel stated that one " . . .should consult reports of the U.S. Office of Education and of the U.S. Department of Labor, masters and doctoral dissertations (which probably comprise the bulk of published research in the field), and descriptive reports from individual institutions (which certainly exist in profusion and could provide most of the factual basis from which conclusions could be drawn)".[2]

All material referenced in this paper was found in the ERIC publications AIM and ARM. Those studies chosen for summary were available on microfiche and no older than 1969. This is because electrical-electronics technology changes very rapidly, making any curriculum study older than about four years of questionable value.

Figure I in the appendix presents the bibliography of studies. All applicable studies found concerning electrical-electronics cur-

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2. Ibid., p. 45.

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riculum are listed including those listed in the bibliography for this paper. The references are ordered according to date of publication and include the ERIC microfiche number.

Inspection of this list indicates that electrical-electronics studies (and probably engineering technology studies in general) can be classified in three very general categories:

1. Curriculum Assessment - Studies of this type recommend addition of new courses or redefinition of old courses based on feedback from industry. From Figure I, studies 1, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 21 would fall in this category.
2. Curriculum Intercombination - Based upon perception of industrial need, this type of study proposes hybrid curriculum representing a horizontal slice across several extant technologies. Examples of this type of course are electro-chemical, electro-mechanical, bio-electrical, etc. Studies number 2, 3, 6, 17, 19, 22 fall in this category.
3. Instructional Innovation - This type of study deals with new methods of teaching technology. Only one of the studies listed in Figure I, number 5, falls into this category. It has implications for all kinds of technology education but happens to use an electronics course as an example, making it applicable to this paper.

A study of the curriculum assessment type is a 1970 publication

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of the University of Illinois concerning electronic-power technology.[3] The need for this guide is established as resulting from a 1966, two-day conference. Representatives from industry, junior colleges and universities met to discuss the technician manpower needs of the electrical power industry. Other significant contributions came from electronic teachers attending National Science Foundation-sponsored academic academic year institutes for 1964-65, 1966-67, and 1968-69 at the University of Illinois.

Contained in the study is an excellent discussion of the philosophy of engineering technology education, including the following observation concerning engineering technology curriculum:

> An engineering technology curriculum is a minimum two-year program of four semesters or six quarters leading to an Associate Degree. It is a college level program but differs significantly from a pre-engineering curriculum. The first two years of an engineering curriculum are primarily devoted to mathematics, science and general education, with very few specialized technical courses. On the other hand, an engineering technology program must initiate specialized technical courses early in the program if the desired objectives are to be accomplished within the time available. The sequencing of courses and topics must be carefully organized to permit the student to develop to the desired levels of competence. An engineering technology curriculum must conserve the rigor of effort on the part of the student that is equivalent to the rigor of effort required in a college program.
>
> An engineering technology curriculum must be structured so that it prepares its graduates functionally:
>
> 1. To enter into a job and be immediately productive with a minimum of on-the-job training.
>
> 2. To provide the technical and scientific background to prepare him to keep abreast of developments in technology throughout his career.
>
> 3. To enable the graduate with a reasonable amount

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3. Advisory Committee, Electronic-Power Technology: A Suggested Two-Year Post-High School Program, University of Illinois, Urbana; June, 1970 (VT-EPIC Set, ED 052 390, VT 011 723)

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> of industrial experience to advance into positions of increased responsibility.
>
> In addition, it must also include sufficient work in the non-technical area to prepare the individual to participate fully in the society of which he is a part.[4]

Perhaps the most impressive component of this quote is the last sentence which, unlike the other studies mentioned in this paper, specifically recognized the need for general education.

The proposed six-quarter curriculum resulting from this study is shown in Figure II of the Appendix. It is stated in the preface that this curriculum contains certain core courses with which other technical elective courses could be added for other options such as electronic-computer science technology, electronic-communication technology, electronic-control systems technology, electronic-data processing technology or other such combinations. Presumably this would involve revision or replacement of the seven different courses in which the contents are power-oriented.

Two most important features of this curriculum are that (1) a computer course is scheduled in the second quarter, i.e. the earliest possible time, with the obvious expectancy of having the student apply computer techniques for the remainder of his courses, and (2) the program provides two natural "break-off" points at the end of the first and second term. As is pointed out, this is especially important in community and junior colleges.

Another study of the curriculum assessment type is a 1969 publication by the Texas Education Agency.[5] The purpose of the study

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4. Ibid., pp. 1-2.

5. Wright, Jerauld B., An Investigation into Public Post-Secondary Electronic Technology Programs in Texas with Implications for Planning, Texas Education Agency, 1969 (ED 034 028)

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was to collect data to help the Texas Education Agency in developing electronic technology programs. Although referred to as a funded project, no clues are given as to the source of the funding, nor is it clear why the agency felt the need for this data.

Information was collected via a survey form that listed 421 units of curriculum instruction and requested responses concerning (1) emphasis which should be given for each unit in electronic technology curriculum, and (2) estimates of future importance of these needs. The form was sent to both schools and industries and also sought information on present and future manpower needs.

Analysis of the data was done by checking for differences in response between schools and industries and between two sectors of industry (communication-oriented and manufacture-oriented) for each of three hypotheses. This was done using the chi-square test of independence of two variables.

Results indicated that schools and industry differed with respect to teaching emphasis for 192 of the 421 units, and that different industries differed with respect to teaching emphasis for 227 units. Schools and industry were in rough agreement on future teaching emphasis, differing on only 18 units.

A study in the curriculum intercombination category is a 1970 publication by William G. Welch, Sr. concerning bio-medical electronics.[6] As a basis for his work, Mr. Welch quoted from a study done by the Technical Education Research Center, Inc. in Cambridge,

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6. Welch, William G., Sr.; The Determination of a Technical Core Curriculum for a Two Year Technical Program in Bio-Medical Electronics, LaCrosse, Wisconsin; Western Wisconsin Technical Institute; July, 1970 (ED 056 220)

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Mass. which referred to the proliferation of specialized equipment in the field of medical technology and the need for technicians to service and maintain it.

To determine the extent of the need for bio-medical electronic technicians (BMET's), a survey was sent to 62 hospitals, clinics, medical centers and medical research institutions and to 19 manufacturers of bio-medical electrical equipment. Respondents were asked to rate agreement or disagreement with statements concerning BMET education on a 1 to 5 scale (Likert scale for opinion response to positive statements).

The results of this survey showed the greatest need for BMET's in maintenance and servicing. A committee of experts in the field examined the survey results and added other objectives. The six-quarter curriculum resulting from all considerations is shown in Figure III of the appendix. Mr. Welch concluded by recommending a clinical experience or internship be associated with the program.

Another study of the hybrid group is a 1970 publication by Roney and Phillips, "Electromechanical Technology".[7] This work was developed under the Occupational Education Project of the A.A.J.C., a project sponsored by the W.K. Kellog Foundation.

The study observed that research to quantify the demand for electromechanical technicians has been limited; however, available results do indicate that a major effort is required of the educational system to meet the E.M. technician need. As evidence of this demand, the study cited a need projected by the computer in-

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7. Roney, Maurice W. and Phillips, Donald S., Electromechanical Technology, American Association of Junior Colleges, 1970 (VT-ERIC Set# ED 054 390, VT# 011 975)

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dustry of about 200,000 technicians during the ten-year period of 1966-75. That this need is largely for E.M. technicians is shown by the fact that one large company's technicians spend 85% of their time on input/output devices. Also cited by the study is Norman C. Harris' paper, "Identifying New and Emerging Occupations", which showed a substantial need for E.M. technicians. Roney did a study at Oklahoma State University in 1966 for 93 organizations which projected a need for 20, 329 trained E.M. technicians by 1970. This is 50% greater than the projected combined need for electrical and mechanical technicians and is more impressive when it is considered that the electronic program outputs alone are still short of the demand.

Educational requirements of emerging "cross-cutting" technologies should be met by use of a core studies program. The common elements of a number of technologies could be combined in a first-year core with mathematics, science and specific industrial applications.

Courses and course content for the electro-mechanical program are based primarily upon a 1966 field study by Roney at O.S.U. This study made four recommendations concerning curriculum design in this field and further stressed the need for new courses combining electrical and mechanical principles.

Figure IV in the Appendix shows a block diagram of the core studies program. Figure V shows the proposed basic engineering technology curriculum for four semesters (including course credits) and details of the 3rd and 4th semesters of electromechanical and

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electronic courses based on this core.

The study to be examined in the area of instructional innovation is a 1970 investigation into systemized study.[8] The study evolved from what the Waukesha County Technical Institute felt were shortcomings in the traditional approach to education. It was their view that a learner-centered approach to education would be more instructive than the traditional teacher-centered approach.

The method of attaining learner-centered education was referred to as the "closed loop systems approach to instruction". This approach was described as having three basic components: (1) a behaviorally stated student performance objective, (2) a means to best carry out the objective, and (3) a means of evaluation and upgrading. A block diagram of this instructional method is shown in Figure VI.

One of the important characteristics of this method is that the learner proceeds at his own pace. At the time he can demonstrate that he has attained the course objectives he is said to have passed the course.

To identify the skills required of electronic technicians in industry, a survey form (referred to in the publication as a test-analysis instrument) was mailed to 287 industries in Milwaukee, Chicago and Minneapolis-St. Paul areas. As a result of this survey, the following units of study were developed for a first course in electronic circuits:

1. Basic Circuits - 10 specific skills identified

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8. Natalizio, A.J.; Instructional Systems Study - Electronics Technology; Waukesha, Wisconsin: Waukesha County Technical Institute, 1970 (ED 048 472)

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2. Complex Resistive Circuits - 3 specific skills identified
3. Meters and Measurement - 3 specific skills identified
4. Magnetism - 14 specific skills identified

The course objectives to be obtained as a result of mastering these skills are listed in Figure VII. Unfortunately, no information was available on the success or failure of this approach.

Conclusion

The motives for these studies are not easily isolated. The Waukesha County Technical Institute felt restless about its instructional program. The University of Illinois held a conference from which emerged the need for a power technician course. Previous studies and other data from the literature prompted the investigations in electromechanical and bio-electrical technology. It is interesting that only one of the studies was conducted with a specific course at a specific institution in mind. The curriculums in the Appendix are meant to be applied in a variety of different programs and are valuable for that reason.

Each of the sample studies, excepting one, relied either directly or indirectly on a survey of industry to define required skills. (The one exception is the electronic-power study which apparently utilized institutes and conferences as resources.) The development of the survey form and the choice of industry representatives to survey appears to be a critical part of a curriculum study.

Although the Texas Education Agency study does not conclude with a curriculum, it does arrive at the interesting results con-

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cerning amount of teaching emphasis that were mentioned previously. The fact that there is greater disagreement between different factions of industry than between schools and industry may indicate that the junior colleges and technical schools are generalizing their curricula to meet everyone's needs. This may indicate the need for interdisciplinary options such as electronic-power and electromechanical.

The Waukesha County study also does not conclude with a curriculum, but it does offer a method of instruction which seems particularly applicable to the field of electronics technician education. This is so because each course of such a curriculum can be broken down into a list of required objectives as shown in Figure VII. The value to the student of such a breakdown is further enhanced by the close coordination required with industry to arrive at a detailed objective list for an entire curriculum.

Three ofthe studies did conclude with specific curriculum proposals. Comparing Figures II, III, and V, it is reassuring to note that all three are in essential agreement for the first year; each program proposes courses in circuit analysis and basic electronics. The electronic-power technology program is unique in introducing a computer science course the second quarter. The BMET curriculum waits until the fifth quarter and the EMT program does not include one at all. All programs have a pulse circuits course in the second year, although it is called digital electronics in the EMT curriculum. The electronic-power program has one more electronic course, network analysis, and completes with power courses.

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The EMET program also has one other course, non-linear electronic circuits, and then completes with bio-medical courses. The electronics phase of the EMT program is complete with the digital electronics course, but since this is a semester course it would be expected to encompass more than the quarter courses.

These results seem to indicate that a core studies program in electronics can be developed. As shown by these examples, it can be combined with other disciplines to yield a number of interdisciplinary programs. It was suggested in the electromechanical technology study that this type of curriculum represented a third generation in technical education development. If so, one can expect to see many more hybrid technologies in the future.

There are several implications of these results to my personal objective of developing some phase of an electrical-electronic curriculum for community colleges. Assuming these studies are representative of work being done, the trend is toward hybrid technologies. Further research in doctoral theses and journals must be done to ascertain what technologies seem to be emerging, requiring new course developments. Also, since the Waukesha County study was the only one found in the area of new methods for technical education, much work could be done in this field.

It can now be seen that Mr. Hull was not quite correct. As shown by Figure I and the studies summarized in this paper, much work has been done on electronics curriculum in the junior college. Unfortunately, some of these studies are already obsolete because of technological change. Technical curriculum will have to be a subject for constant study and updating in order for the junior

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college to play a significant role in meeting the demands of technology.

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FIGURE I

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3. Roney & Phillips, "Electromechanical Technology", 1970 (ERIC # 054 390, VT-ERIC Set; VT # VT 011 975)

4. University of Illinois, Urbana: "Electronic-Power Technology; A Suggested Two-Year Post-High School Program. Engineering Technology Series #5", 1970 (ERIC # ED 052 390, VT-ERIC Set; VT # VT 011 723)

5. Waukesha County Technical Inst., Wisconsin, "Instructional Systems Study, Electronics Technology", 1970 (ERIC # ED 048 472)

6. Welch, "The Determination of a Technical Core Curriculum for a Two Year Technical Program in Bio-Medical Electronics", 1970 (ERIC # ED 056 220)

7. Wright, "An Investigation into Public Post-Secondary Electronic Technology Programs in Texas with Implication for Planning", 1969 (ERIC # ED 034 028)

8. Crozier & Butler, "The Electronics Curriculum. Eleventh Quarterly Technical Report", 1969 (ERIC # ED 029 156)

9. Simons, "Relative Understanding of Mathematical Concepts by Students Majoring in Electronics Technology", 1968 (ERIC # ED 062 579, VT-ERIC Set; VT # 007 648)

10. Stephenson, "The Effectiveness of the Contra Costra College Electronics Program in Preparing Its Graduates for Employment as Reported by Post-Graduate Students", San Pablo: Contra Costra College, 1968 (ERIC # ED 017 271)

11. Washington, D.C., Office of Education: "Criteria for Technician Education, A Suggested Guide", 1968 (ERIC # ED 027 417)

12. Dobrovolny, "Electronic Technology, A Suggested Two-Year Post High School Program", Urbana, Univ. of Illinois, 1967 (ERIC # ED 014 302)

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21. University of Illinois, Urbana: "Electronics Technology, A Suggested 2-Year Post-High School Program. Engineering Technology Series No. 2", 1964 (ERIC # ED 034 074, VT-ERIC Set; VT # VT 000 432)

22. California State Dept. of Education, Sacramento: "Electromechanical Technology, Educational Needs of the Technical Worker", 1963 (ERIC # ED 042 931, VT-ERIC Set; VT # VT 004 150)

FIGURE II*

Electronic-Power Technology
(A Suggested Two-Year Curriculum)

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Course	Hours			
	Class	Laboratory	Contact	Credit
1st Quarter				
Mathematics I (Algebra & Trig.)	5	0	5	5
Introduction to Electronics Technology	0	6	6	2
Communications I	4	0	4	4
Mechanical Drafting	1	6	7	3
Psychology of Human Relations	4	0	4	4
	14	12	26	18
2nd Quarter				
Mathematics II (Trig. & Introduction to Calculus)	4	0	4	4
Computer Science	3	2	5	4
Circuits I (Resistive Circuits)	4	3	7	5
Communications II	3	0	3	3
Electrical-Electronic Drafting	1	4	5	2
	15	9	24	18
3rd Quarter				
Mathematics III(Calculus)	5	0	5	5
Electronics I (Resistive Electronic Circuits)	3	3	6	4
Circuits II (STC Circuits)	4	3	7	5
Physics I	3	2	5	4
	15	8	23	18
4th Quarter				
Mathematics IV (Introduction to Differential Equations)	3	0	3	3
Electronics II (Pulse Circuits)	3	3	6	4
Circuits III (Network Analysis)	3	3	6	4
Physics II	3	2	5	4
Industrial Organization & Operation	3	0	3	3
	15	8	23	18
5th Quarter				
Industrial Electronics (Devices)	2	3	5	3
Physics III	3	2	5	4
Introduction to Power Circuits	3	3	6	4
Economics of Industry	3	0	3	3
Technical Report Writing	3	0	3	3
	14	8	22	17
6th Quarter				
Industrial Electronics II(Systems)	1	3	4	2
Energy Conversion	3	3	6	4
Energy System Controls	3	3	6	4
Transmission Lines	3	3	6	4
Nontechnical Elective	3	0	3	3
	13	12	25	17

* Advisory Committee, Electronic-Power Technology: A Suggested Two-Year Post High School Program, University of Illinois, Urbana; June, 1970 (VT-ERIC Set# ED 052 390, VT# 011 723); p.10.

FIGURE III#

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Bio-Medical Electronics

Proposed Curriculum

	Credit	Class	Lab
First Quarter			
Communications Skills 1	3	3	0
Technical Mathematics 1	5	5	0
Electronic Methods 1	3	1	4
DC Circuits	4	2	4
*Introduction to Bio-Medical Electronics	3	2	2
	18	13	10
Second Quarter			
Communications Skills 2	3	3	0
Technical Mathematics 2	5	5	0
Technical Physics 1	3	2	2
AC Circuits	4	2	4
*Physiological Processes 1	3	2	2
	18	14	8
Third Quarter			
Social Science	3	3	0
Technical Mathematics 3	4	4	0
Technical Physics 2	3	2	2
Active Devices	4	2	4
*Physiological Processes 2	3	2	3
	17	13	9
Fourth Quarter			
Social Science	3	3	0
Technical Physics 3	3	2	2
Linear Electronic Circuits	5	3	4
Pulse Circuits	3	2	2
*Bio-Medical Techniques 1	3	2	2
	17	12	10
Fifth Quarter			
Social Science	3	3	0
Social Science	2	2	0
Non-linear Electronic Circuits	4	2	4
Introduction to Computer Science	3	2	2
*Bio-Medical Techniques 2	3	2	2
*Medical Instrumentation 1	3	2	2
	18	13	10
Sixth Quarter			
Communication Skills 3	3	3	0
Social Science	3	3	0
*Bio-Medical Techniques 3	3	2	2
*Medical Instrumentation 2	3	1	4
*Medical Instrument Construction and Application	3	1	4
*Elective any area	3	2-3	0
	18	12-13	10

* Technical Core courses specifically developed for this technology.

\# Welch, William C., Sr.; The Determination of a Technical Core Curriculum for a Two Year Technical Program in Bio-Medical Electronics, LaCrosse, Wisconsin: Western Wisconsin Technical Institute; July, 1970 (ED 056 220); p. 85.

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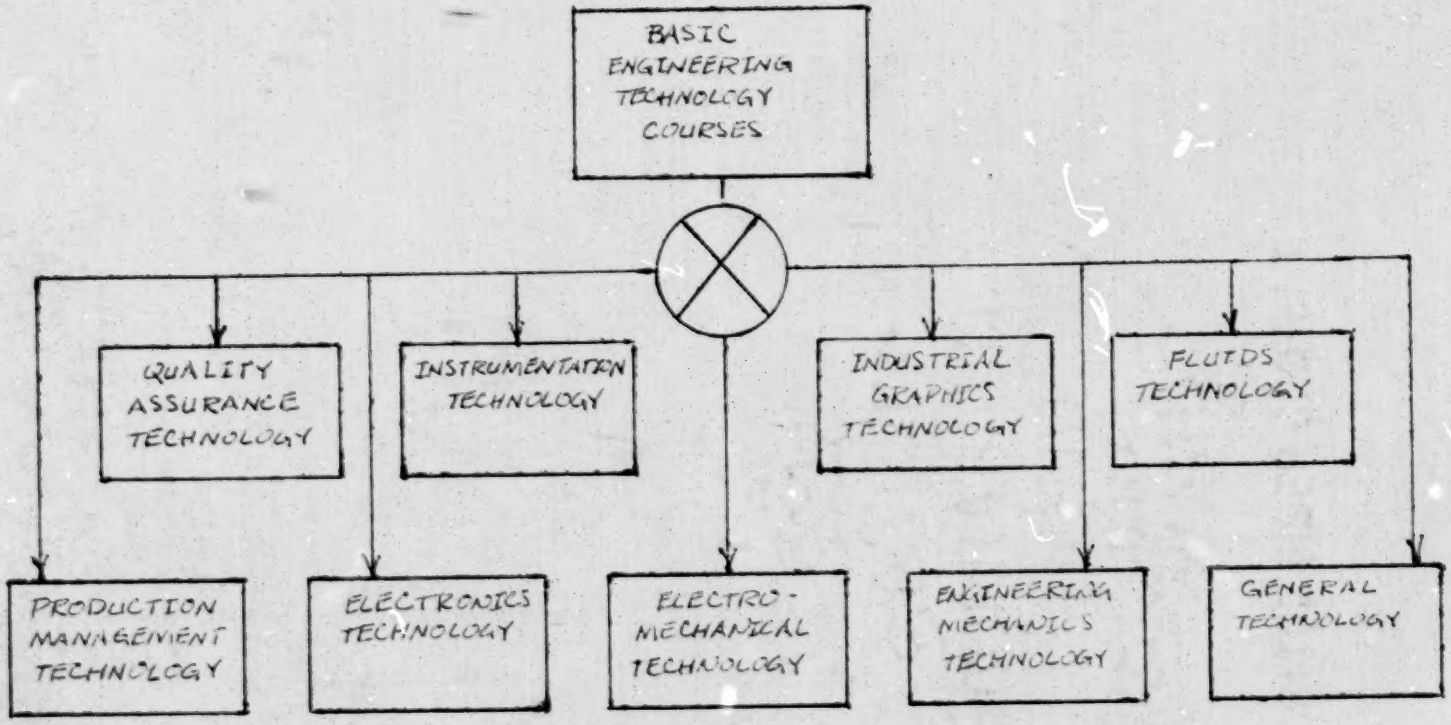

FIG. IV

NUCLEATE TECHNICAL CURRICULUMS

Roney, Maurice W. and Phillips, Donald S., Electromechanical Technology, American Association of Junior Colleges, 1970 (VT-ERIC Set# ED 054 390, VT# 011 975), p. 37.

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FIGURE V*

Foundation Courses For

Basic Engineering Technology

First Semester

	T	L	C
Unified Physics 1	3	2	4
Electric Circuit Analysis	2	4	4
Introduction to Mechanics	2	4	4
Algebra and Trignometry	3	0	3
Technical Report Writing	1	0	1
Orientation and Library Science	1	0	1
Totals	12	10	17

Second Semester

Unified Physics II	3	2	4
Introduction to Electronics	2	4	4
Mechanisms	2	4	4
Electromechanical Components	1	3	2
Calculus and Analytic Geometry	3	0	3
Totals	11	13	17

Third Semester

Advanced Technical Courses	*	*	10
American History	3	0	3
English	3	0	3
Physical Education I	0	3	1
Totals			17

Fourth Semester

Advanced Technical Courses	*	*	11
American Government	3	0	3
Technical Communication Skills	2	0	2
Physical Education II	0	3	1
Totals			17

* Number of hours varies

Electromechanical Technology

Third Semester

Digital Electronics	2	4	4
Electromechanical Controls	1	3	2
Mechanics of Materials & Processes	3	3	4
Totals	6	10	10

Fourth Semester

Servomechanisms	2	4	4
Process Control	3	3	4
Manufacturing Materials & Processes	2	3	3
Totals	7	10	11

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Electronics Technology

	T	L	C
Third Semester			
Digital Electronics	2	4	4
Electronic Metrology	2	4	4
Electromechanical Controls	1	3	2
Totals	5	11	10
Fourth Semester			
Electronic Communication	2	4	4
Servomechanisms	2	4	4
Pulse and Wave Shaping	2	3	3
Totals	6	11	11

* Roney, Maurice W. and Phillips, Donald S., Electromechanical Technology, American Association of Junior Colleges, 1970 (VT-ERIC Set# ED 054 390, VT# 011 975)

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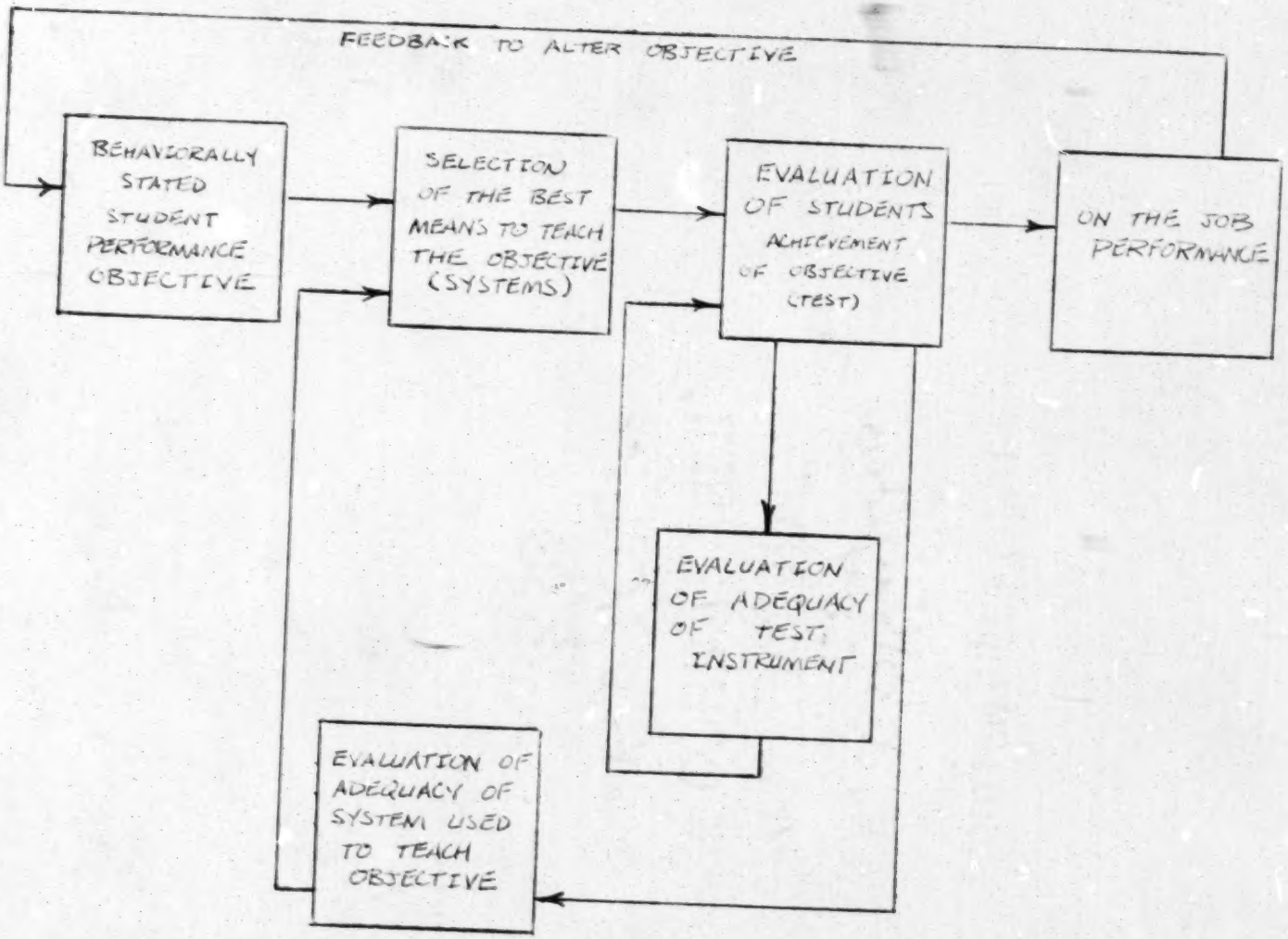

FIG. VI

THE CLOSED LOOP SYSTEMS APPROACH TO INSTRUCTION

Natellizio, A.J.; Instructional Systems Study- Electronics Technology; Waukesha, Wisconsin: Waukesha County Technical Institute, 1970 (ED 048 472); p. 20.

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FIGURE VII*

Waukesha County Technical Institute
Circuits I

Course Objectives

By the completion of the course students will be able to:

1. Apply the basic electrical properties of voltage, current, power and resistance to the analysis of electronic circuit problems.

2. Design and construct voltage dividers, current dividers, bridge networks, volt-ohm meters, and other series-parallel resistive networks connected to one or two generators.

3. Determine the voltage, current, resistance and power characteristics of any of the resistive circuits listed in objective #2, through mathematical analysis.

4. Describe, and mathematically compute, the magnetic flux density, magnetomotive force and permeability of a ferromagnetic series circuit.

5. Describe the magnetic action through which motors convert electrical power to mechanical, and generators convert mechanical power to electrical.

6. Compute and measure the effective, average, peak and instantaneous voltage of a given sine wave.

* Natalizio, A.J.; Instructional Systems Study-Electronics Technology; Waukesha, Wisconsin: Waukesha County Technical Institute, 1970 (ED 048 472); p. 31.